AD-A125 091 INTEGRATED NUCLEAR AND CONVENTIONAL THEATER WARFARE SIMULATION (INWARS) L..(U) BDM CORP MCLEAN VA 24 JUL 78 BDM/W-78-402-TR-VOL-2 DAAG39-77-C-0174

1/1

UNCLASSIFIED

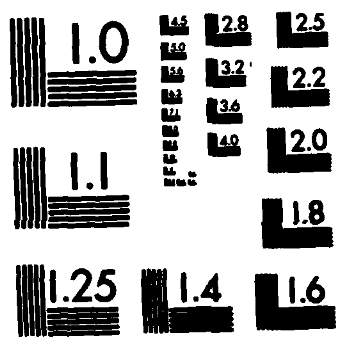
F/G 15/4

NL

END

FILMED

DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

THE BDM CORPORATION

7915 Jones Branch Drive
McLean, Virginia 22102
Phone (703) 821-5000

24 July 1978

BDM/W-78-402-TR

Contract DAAG39-77-C-0174

(DRAFT)

INTEGRATED NUCLEAR AND CONVENTIONAL THEATER WARFARE SIMULATION (INWARS) LEVEL III SPECIFICATIONS

VOLUME II: GROUND COMBAT MODELING

This document is submitted to Headquarters, Department of the Army, Office of the Deputy Chief of Staff for Operations and Plans, ATTN: Mr. P. E. Louer (DAMO-ZD) Washington, D.C. 20310

FOREWORD

This document is Volume II of five volumes presenting the Level III Specifications for the Integrated Nuclear and Conventional Theater Warfare Simulation (INWARS) under development for the U.S. Army by the BDM Corporation. This volume is concerned with the ground combat modeling.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

CHAPTER I
INTRODUCTION AND SURVEY

This volume will discuss the methods with which the INWARS model will represent the ground force units and their interactions with friendly and enemy units. This structure follows in general that used in previous models by BDM, with enhancements made to automate the command control process.

A. OVERVIEW

The ground combat model provides the background against which decisionmaking processes in The Command, Control and Intelligence (C^2I) portion of the INWARS model take place. If the results of an input to the C^2I process are to be valid, the ground combat model must be a reasonably accurate simulation. The choice of scale, resolution, and detail in the various ground combat processes are based on this viewpoint.

1. Unit and Terrain Resolution

The choice of resolution for basic units and terrain is as follows:

a. Units

For INWARS the basic, or smallest echelon, units represented are brigades and regiments. This stems from the philosophy that a commander keeps track of events two echelons down, and issues commands one echelon down. As the lowest level decisionmaking which will plan and execute nuclear/chemical operations is the corps and army for Blue and Red respectively, the representation of the second echelon down requires that the basic units be the brigade and regiment. This is the level at which the various tactics, such as envelopment, penetration, etc., will be executed and perceived.

b. Terrain

The basic distance resolution of 9.5 km was chosen as most appropriate for representing the maneuver of brigade or regimental sized units. This requires no unit to extend its control over more than a 3 hex front, which is a practical limit for software implementation, yet still allows enough resolution to represent maneuver.

It is necessary that the decisionmaking units, e.g., corps, be able to recognize critical conditions as they develop. At the 9.5 km level, a gap of significance could develop for which an action at CORPS level might correct, while at the next level hex, 25 km, a gap when recognized would probably already be beyond the ability of CORPS to handle.

2. Treatment of Detail

In INWARS the use of a large number of basic regimental and brigade sized units allows simpler treatment of the details of combat interactions than might be appropriate for fewer large units. Various aspects of these details can be divided into two categories, depending on whether the effect will tend to average out over a large number of events, or whether the effect does not loose significance when the large number of interactions in INWARS are considered. An example of the first category might be the resolution of distance between individual units. While an attrition equation which resolves and uses the actual distance along a path between the hexes occupied by opposing units might be develped, this effect should average out when the overall effect of the actions over time and all of the units in the area. On the other hand, an error in an attrition rate would accumulate over all processes, and might distort the overall results. This would be an example of the second category.

The design of the ground combat has emphasized the accurate representation of the effects in the latter category, while leaving out detail in the first category where it would require significant increases in software complexity or run time. The use of large numbers of relatively small units in INWARS has allowed much of the complexity in the first category to be left out, simplifying the software design.

3. Software Design

The software design phase of the INWARS development has had a strong influence on the model development. Many ways of performing processes which might seem simple from an operational point of view have been very complex in their requirements on the software, whereas some rather complex processes have proved to be possible with only marginal or almost no difference in software design. Tradeoffs necessary to provide an adequate model within level of effort constraints have been detailed in some, but not all, segments of the model design that follows.

4. Components

The ground combat components of INWARS can be functionally divided into entities, acts, and processes.

a. Ground Combat Entities

The various ground combat entities in INWARS discussed here are illustrated in figure I-1.

(1) Brigades/Regiments: The representation of Brigades and Regiments is a principal design focus. These units contain the basic weapons and targets whose combat interactions play a dominant role in determining the course of the battle.

(2) Divisions: This entity is actually considered a "player", since it controls other entities and engages in planning. The division itself will not be represented on the map, although a division headquarters entity will, as well as the component brigade or regiment entities.

(3) Pools: This class of entities is not represented by explicit units and locations on the map, but represents a collection of assets which may be assigned to other entities. Pools for missiles, attack helicopters, and artillery will be included in INWARS. The assignement of assets is made by a C^2I element above division level, and is implemented by attaching the weapons to a particular ground combat entity.

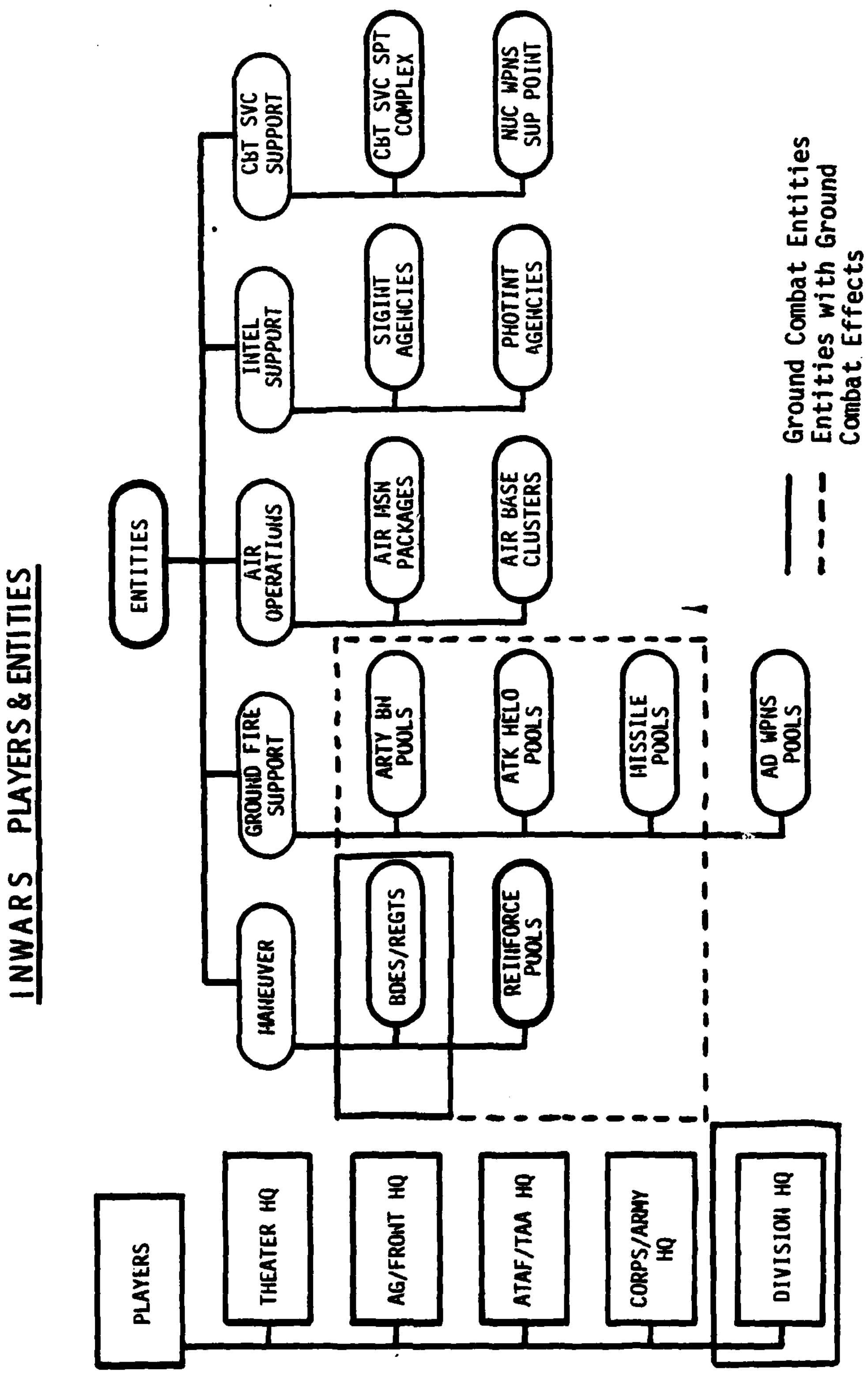


Figure I-1. Ground Combat Entities

Pools are always associated with headquarters entities, and can be attritted in association with them.

(4) Headquarters: These are entities similar to brigades and regiments from a software perspective in a combat/movement context, but with different behavior and use. They provide a means for attacking and disrupting the C^2I processes, and attritting associated pools. Division Headquarters will normally have attached artillery which is used for General Support missions. Headquarters may also have limited direct fire assets for self defense.

b. Continuous Ground Combat Processes

Unlike the other parts of INWARS, a large portion of the ground combat processes are time step driven rather than event driven. This was done to allow software simplification; some of these aspects are discussed in Chapter V, Section B. While processes are normally the consequences of acts, in the ground combat section the time step driven processes are not, and will be referred to as continuous processes. These are listed below:

(1) Perception: In this process an entity examines other nearby hexes and acquires a perception of enemy units. There are separate processes for brigades/regiments and divisions.

(2) Attrition: This process includes attrition resulting from conventional ground force weapons. It uses information acquired during the perception process.

(3) Movement: Various entities move in accordance with their orders and the situation.

(4) Operation Consideration: In this process an entity examines its situation and changes its operation accordingly if required. Planning and other actions may result.

(5) Reconstitution: In certain circumstances a unit may be able to reconstitute. When this is true, reconstitution proceeds as an incremental, continuous process.

c. Acts

The principal act executed by entities is the initiation of messages, although there is provision for others.

(1) Messages: Messages to Corps/Army are initiated in certain circumstances. These may be of intelligence, operational, or status nature.

(2) Other Acts: The structure has been provided for the future inclusion of other acts if necessary.

B. SEQUENCE

In INWARS combat and movement will be synchronized; at fixed intervals a routine will compute combat, intelligence, and movement for each unit, as follows:

(1) Intelligence - Each entity will search its own hex and all adjacent hexes, and compute values for threat and friendly presence associated with each hex. This might be supplemented by additional information made available from the division level.

Event driven Time by sequence

(2) Combat - The unit will allocate its fire among the enemy units. Attrition of enemy units would then be computed, and inflicted.

(3) Operation Effects - Intelligence information and the unit's current status will be used to derive a situation code, which will then be used to look up the unit's change of operation and mission, calls for support, initiation of messages, and other actions as appropriate.

(4) Movement - The unit will then move an increment of distance within its hex in accordance with movement effects such as attrition sustained, operation, etc. When it arrives at the center of a hex, and on certain other occasions the direction for future movement will be chosen.

(5) After the above cycle is completed for the entities attached to a division, the steps are repeated for the division headquarters. Subsequently, all temporary storage blocks are returned to conserve space.

(6) The order in which the sides are processed will be reversed on alternate intervals so that the effects of discrete intervals will not give a net advantage to either side.

C. SURVEY

Chapter II will discuss the actual structure and components of the individual ground combat units. Then, in Chapter III, the method for intelligence acquisition and situation description will be presented. This is then used to modify the operational behavior of the units, and to initiate various actions, as described in Chapter IV. Chapters V and VI discuss the movement and combat mechanisms, and Chapter VII the method for reconstituting units and incorporating replacements.

CHAPTER II
GROUND UNIT DESCRIPTION

A. INTRODUCTION

All of the ground units described can be considered entities, which are represented in the model by a data block called the unit scoreboard. This contains data which defines the unit's position in the command control structure, as well as other information necessary to define its physical characteristics. Division headquarters entities are also considered players, since they are capable of performing low level planning. However, their representation must be very limited due to the impact that their large number could make on space and computation time. Special entities described as pools will be implemented as entities like brigades, but with different equipment or other characteristics, or as part of other entities such as division headquarters.

B. ORGANIZATION OF FORCES IN TERMS OF BRIGADES/REGIMENTS

1. Brigade/Regiment Makeup

The basic units in INWARS, brigades and regiments, will be inputs into the simulation, although some will not be present as individual entities but as part of replacement/reinforcement pools. To simplify input and input and entity generation, these units will be classified into different types, with all units of a given type having the same assets. Thus, it is necessary only to input the composition of a Red tank regiment once instead of hundreds of times. In a similar manner, standard organizations could be used for divisions, with a standard type of division having certain numbers of attached standard regiment types. This would be most useful for further simplifying Red inputs. Figure II-1 illustrates the use of this method.

INWARS

UNIT COMPOSITION

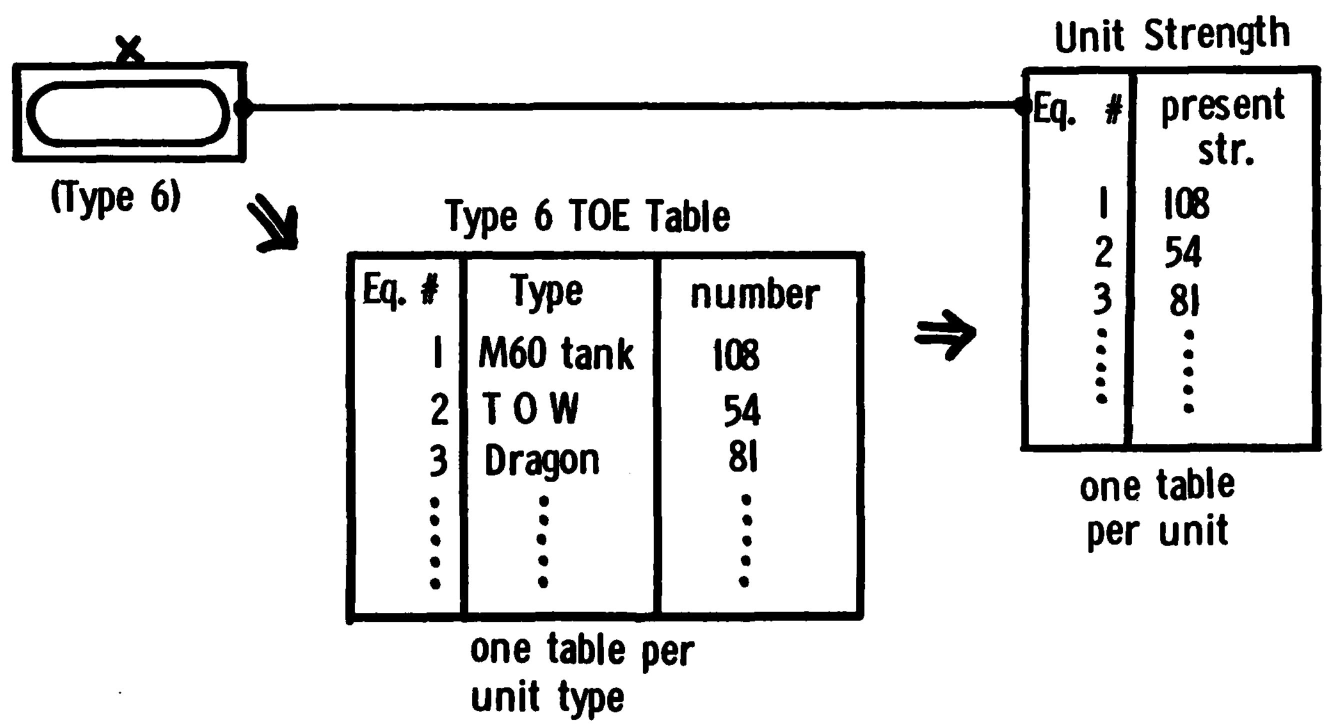


Figure II-1. Standard Type Unit Composition

2. "Fitting" Forces into Brigades/Regiments

Some compromises may be necessary to fit "real" force structures into the INWARS Brigade/Regiment structure. This is especially the case for NATO whose component national forces may not be as uniform in organization as the Warsaw Pact forces. For example, the British Army of the Rhine (BAOR) is currently being reorganized into four armored divisions and a Field Force. Each Division will be composed of 5 Battalions with no Brigade organizations. In representing this situation in the model, some modification will be necessary. For example, it may be necessary to create two notional "Divisions" which have as their "Brigades" two of the actual armored Divisions. The Field Force would be considered to be a separate "Brigade" size force. The BAOR would thus consist of two "Divisions" and a "Brigade" in INWARS.

3. Association of Brigades/Regiment with C^2I Elements

Brigades/Regiments may be associated with C^2I elements in two forms: (1) as individuals, or (2) as components of a reinforcement pool. Corresponding to these two forms of association are two modes of command and control. The individual mode of command and control entails development of detailed operations directives to guide the actions of particular Brigades/ Regiments as well as the subsequent control of the directed operations. The reinforcement pool command and control mode involves only the allocation and assignment of individual Brigades/Regiments in the pool to subordinate C^2I elements.

The reinforcement pool itself represents units retained by higher level C^2I elements and also provides for the external flow of reinforcing units into the theater. Depending on the scenario and warning times involved, REFORGER units might be part of this external "resupply". When units arrive in the external resupply stream, they will initially be placed in the reinforcement pool at the Theater level. Units will remain in this pool until the Theater C^2I element decides to assign the unit(s) to specific subordinates. Units in the reinforcement pool will not be spatially located. When in a reinforcement pool, the units will be associated with the C^2I element's location. When a unit in this pool is assigned to a

particular subordinate unit, it will "move" to the assigned C^2I element by scheduling transfer of command after an appropriate delay for travel. In addition to the units flowing into the theater in the external resupply, the user may designate units that are in the theater at the start of the war to be located in various level replacement pools.

As presently envisioned, the individual command and control mode will be exercised only at the Division level. All higher level commands will control reinforcement pools and will thus be limited to assigning Brigades/ Regiments to subordinate commands. This approach has been adopted to reduce the complexity of the command, control, and intelligence (C^2I) processes. In particular, under this approach, detailed Brigade/Regiment control processes will only need to exist at the Division level. The approach does, however, preclude detailed control of Brigades/Regiments by Corps/Army level C^2I elements. Thus, a Corps reserve or separate Brigade would have to be assigned to a division for detailed commitment or employment.

C. ENTITY DESCRIPTION

Each entity is represented by a unit scoreboard which contains the following information:

(1) Command Control - The scoreboard will contain data which indicates where the unit fits into the command control structure. This will consist of pointers to the unit's superior, its first subordinate unit, and one of its sister units. The structure formed by these pointers allows reference to be made to any other unit on the same side, although only the immediate superiors, subordinates, and sister units will actually be used.

(2) Physical Location/Movement - The unit's location in the hexagonal grid and its movement vector are included in the scoreboard. In addition, orientation and sector width will be provided for those entities needing these characteristics.

(3) Operation and Situation States - There will be space provided in the scoreboard for operational and "mental" representations as discussed in Chapter IV.

(4) Nuclear and chemical readiness will be represented in terms of "readiness states" implicitly reflecting measures taken by the Brigades/Regiment to reduce their vulnerability to the respective threats (e.g., dispersing, donning protective clothing, and so forth). The role of these readiness states in the model is to parameterize the benefits and costs of the associated vulnerability reduction measures. Thus, the effects of a nuclear or chemical attack will be reduced to the extent that the Brigade/Regiment is in a higher state of nuclear or chemical readiness. However, high states of readiness may preclude a unit from realizing its full firepower capability in combat processes.

(5) Other Data - In addition to the above information, other types of data will be linked to the entities as needed. These will include the assets of the unit, and those characteristics necessary to represent the division headquarters function.

D. DIVISION DESCRIPTION

The divisions are represented by unit scoreboards, but in addition have attached data to represent their intelligence gathering and situation representation information.

(1) Intelligence List - This is a list of enemy units located and detected by the division. As changes occur, messages are sent to corps.

(2) Situation Representation - This is essentially a local map of enemy and friendly concentrations maintained by the division. This is then used in evaluating the situation.

E. ASSET REPRESENTATION

The various weapons, equipment, and other assets attached to a unit are included in that entity's assets list. For each asset, an asset code, base strength, and present strength will be included. The assets can be in the following categories:

(1) Weapons - These assets are capable of inflicting attrition, and are also targets for enemy weapons.

(2) Non-Weapon Targets - These assets are not attrition inflicting, but are independent targets, subject to enemy fire.

(3) Non-independent Weapons - Each of these weapons fires independently, but is targeted at the same time as the weapons or targets described above, without diluting enemy fire. An example might be infantry personnel, whose attrition could be tied to that of BMP's.

(4) Non-independent Targets - Each of these targets is attritted as are the non-dependent weapons. This could be used to independently represent components of supplies, for example, which are attritted together but which are used separately.

(5) Non-Attrittable Assets - These asset types would not be subject to attrition.

F. POOLS

Most pool assets will exist as weapons attached to some entity, usually a division or other headquarters. Their identification in the asset list will indicate that they may be subject to special processes.

The Corps C^2I logic will be responsible for the distribution of pool type assets; while they are attacked to divisions, brigades, or regiments they will be treated much like other targets and weapons. Assets which will be treated in this way include artillery, attack helicopters, missiles, and possibly air defense.

CHAPTER III
OPERATIONAL INTELLIGENCE AND PERCEPTION

One function of the maneuver units is the acquisition of intelligence. This information is used directly by them for resolution of combat and the reaction process. The same information is used by the divisions in their reaction and planning. The communication of this intelligence within a division is not modeled explicitly. Data is passed directly from the brigades/regiments to the division. Intelligence from or to the division from corps is modeled in the form of explicit messages.

A. ENTITY PERCEPTIONS

At each interval in the entity's combat/movement/reaction cycle each entity searches its own and all adjacent hexes at the 9.5 km level. It detects and subsequently may engage targets in all of these hexes, subject to weapons characteristics. The units found are put into the division data base.

B. DIVISIONAL INTELLIGENCE PROCESSING

After all of the entities in a division have completed their perceptions, the data base formed by them is evaluated. Enemy units are put in an intelligence list.

1. Intelligence List

As enemy units are first detected by the division, they are added to a divisional intelligence list. Associated with each of the units will be times which will indicate when the unit is detected, identified, and time since the last detection. The time to identify and detect can be made dependent on various factors such as terrain, weather, operation, distance from friendly units, etc. Only after the time to detect has elapsed can the division be aware of and plan considering a particular enemy unit; its identification is available only after the

identity timer has completed its run. When new enemy units are detected and identified, messages can be sent to corps. Enemy units are dropped from the list if they have not been detected within a certain time. The intelligence list can be kept for only division level units if desired.

2. Situation Representation

In addition to maintaining the intelligence list, the division also keeps a situation representation in the form of a map at the 25 km level. This is used to compare the present situation to the previous interval situation. Data derived from this representation can then be used to evaluate the situation, and is also used in planning.

C. INTELLIGENCE MESSAGES

Intelligence messages to corps are initiated by the division when a new enemy unit is detected or recognized. It may be best to make this report only for divisions for the blue forces, to limit computation and space cost. In addition, the division will also be the recipient of intelligence messages from corps. The data received would then be incorporated into the Intelligence List and Situation Representation.

D. SITUATION EVALUATION

The information assembled during the perception process must be evaluated for its meaning to the unit. Specific conditions must be recognized so that the unit can respond. This process is basically similar for entities and the divisions, but differs in specifics.

1. Brigade/Regiment Situation Evaluation

The brigades and regiments will evaluate the situation for the following specifics:

(1) Combat Status - whether enemy units are in the same hex, adjacent, or not present

(2) Force ratio - whether the local ratio of enemy to friendly strength exceeds some operation dependent constant. The

same information may be derived from the unit's own attrition rate.

(3) Flanking Threat - whether or not enemy units pose a significant flanking threat

(4) Meeting Engagement or Attack Condition - whether or not the unit is moving into the same hex occupied by an enemy unit or is moving into the same hex into which an enemy unit is also moving, and which is not occupied by friendly units.

(5) Effectiveness - a unit will be classified as being in one of three effectiveness states, determined primarily by casualties and with consideration of supply status. This is dealt with in more detail in Chapter VII.

(6) Other - in addition, the presence of a chemical or nuclear attack will be noted.

2. <u>Divisional Situation Evaluation</u>

The division must evaluate a larger number of conditions, as it must be able to consider maneuver of its component brigades or regiments, as well as movement as a whole.

(1) Combat Status, Flanking Threat, and Meeting Engagement/Attack conditions are similar to those for the entities.

(2) Line Integrity - whether the division's position is intact or not

(3) Flank Security - whether the division's units are in contact with friendly forces or a secure area (sea or possibly a neutral border or impassable terrain) on either flank.

(4) Angular Moment of Enemy Force - This indicates whether the enemy threat is massed significantly more on either flank.

(5) Effectiveness - this will be an overall effectiveness rating at the division based on these of its component entities.

(6) Nuclear/Chemical Envrionment - This indicates the nature of the use of threat of use of these weapons.

CHAPTER IV
OPERATION REPRESENTATION

The heirarchical nature of command relationships results from the practical command limitations of any particular element in the command structure. If large numbers of units are to be controlled, and the C^2I process is to be manageable, INWARS must similarly limit the number of subordinates and the amount of direction required by the subordinate units. To this end, a design goal has been to incorporate as much at the reaction and operations processes as possible into the lower level units as a means of simplifying the higher level C^2I processing. This also allows a more accurate representation of unit actions in the absence of command control due to enemy action. A low level operation representation has been designed which will meet these goals. The basic approach has already been used in the Corps Level Electronics Warfare (CLEW) simulation, where it successfully represented operational effects at the battalion level, with higher echelons played by a man in the loop. The completely automated requirement of INWARS requires modifications and the addition of similar processes to represent the division headquarters.

A. OVERVIEW

The way in which a unit acts and reacts is dependent on its operation orders. Each unit is given an operation order or series of orders which each describe an objective, an operation code for the unit, and an axis which serves to orient the unit with respect to the enemy. The orders may be issued by superior units, or may be self generated in response to a unit's situation. The method for doing this is called the Behavior Generation System, which is functionally a Push Down Automata. The operation code of a unit describes its behavior by setting parameters used in movement, attrition, situation evaluation, and planning.

B. THE BEHAVIOR GENERATION SYSTEM

The INWARS Behavior Generation System is both an extension and a simplification of the operational control mechanism in the Corps Level Electronics Warfare model, (CLEW), which used a finite state machine and a chain of operation orders. It is derived from the Theoretical Push Down Automaton.

1. The Push Down Automaton

The Push Down Automator is an extension of the finite state machine, so it is necessary to describe the latter first.

a. The Finite State Machine

The finite state machine consists of a set of states, and rules for transitions between the states for various input conditions. When an input is made to the machine, it changes state in accordance with a table which describes the machine. An output is also associated either with the transition or with the state. An example of a binary adder, implemented as a finite state machine, is shown in Figure IV-1.

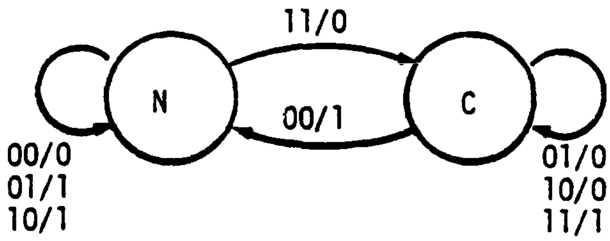
b. The Stack

The Push Down Automaton is a finite state machine to which a "stack" has been added. One of the events which can occur during a transition is that the current state is saved, or pushed down, on the stack. Another possible event is that the stack is "popped", or the top saved state is taken from the stack. In this way, interrupting events, or inputs, can be dealt with without losing track of the processing which preceeded the interrupt. An example of a push down automaton is given in Figure IV-2. In this example a computer is designated to perform three tasks, A, B, and C, inputted in any order. A push down automaton is used to control the processing.

2. Application to INWARS

In INWARS, each entity will be represented as a Behavior Generation System (BGS), with its state representing an assigned mission, the input being its situation, and the output its behavior as outlined in Figure IV-3. This representation is advantageous since it allows all of the

start



1a. State Transition Diagram

KEY:

xy/z

x = 1st binary addend, lsb first

y = 2nd binary addend, lsb first

z = sum output, lsb first

lsb = least significant bit

state

transition

C = carry forward

N = no carry forward

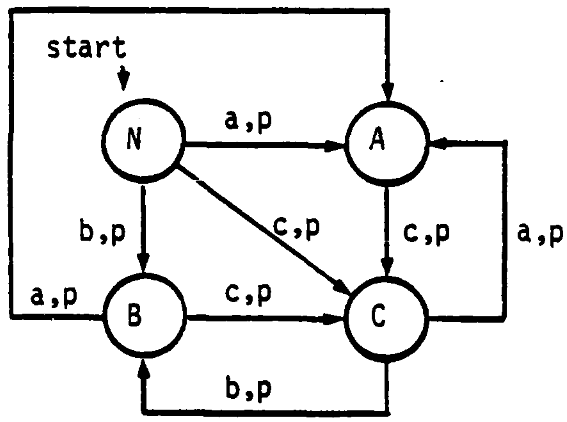
State \ input xy=	00	01	10	11
N	N	N	N	C
C	N	C	C	C

1b. State Transition Table

State \ input xy=	00	01	10	11
N	0	1	1	0
C	1	0	0	1

1c. Output Table

Figure IV-1. Binary Adder Implemented as a Finite State Machine



KEY:

N = idle; no processing

A, B, C = job A, B, or C executing

a, b, c = job A, B, or C entered

p = push current state to stack

n: no input

f: job A, B, or C finished

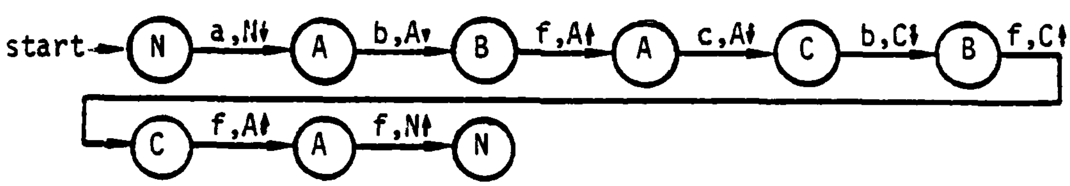
-: job reentry prohibited

pop: pop state from stack

2a. State Transition Diagram

n	a	b	c	f
N	A,p	B,p	C,p	N
A	-	B,p	C,p	Pop
B	A,p	-	C,p	Pop
C	A,p	B,p	-	Pop

2b. State Transition Table



jobs input sequence: A, B, C, B

machine inputs: a, b, f_b, c, b, f_b, f_c, f_a

note: outputs not shown

2c. Example of Execution

Figure IV-2. Push Down Automation Example

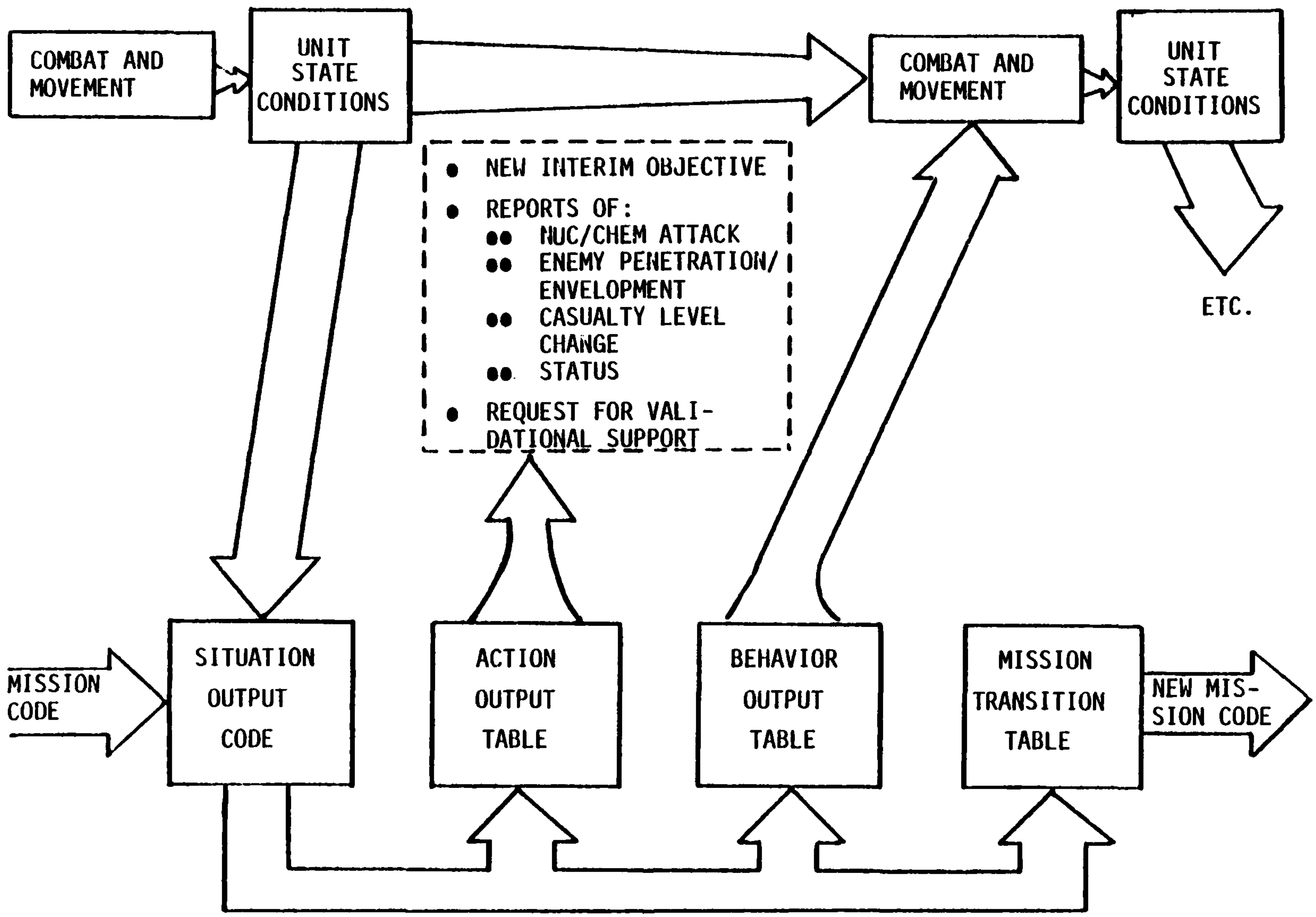


Figure IV-3. Behavioι Generation Overview

peculiarities of various missions and modes of operation to be represented by data, the various state and output tables, rather then by complex decision code. This allows the software to be much simpler, faster, and more flexible. Changes in the way missions are executed, situations are evaluated, and actions are taken can be made without modifying the program in most cases; only the data in the tables need be changed. When the Behavior Generation System is used in this way, the state, input, and output will be used as follows:

(1) State = Operation - The states in the BGS correspond to operations that are being performed by the unit, such as hasty attack, delay, march, etc.

(2) Input = Situation - The input to the BGS will be a code corresponding to the unit's situation. The encoding will include such factors as a unit's effectiveness status, combat status, the enemy threat, and nuclear/chemical envrionment. This is most easily represented by a table which gives the input code as a function of all the various aspects of the situation.

(3) Output = Behavior and Actions - The outputs of the BGS will be in two categories:

   a. Behavior parameters - This will be an operation code which is used to look up a set of parameters governing governing combat and movement. These will include the operational inputs to the attrition equation, criteria used in evaluating movement options, effectiveness breakpoints, delay times, internal disposition, and others.

   b. Action Flags - These outputs initiate actions such as calls for artillery or close air support, initiation of messages, generation of new objectives, or any other single actions appropriate for the unit.

3. Implementation Method

The following steps are used to develop the data and code for implementation of this method:

(1) Coding of the BGS mechanism - since this code is independent of the operation implementation, structures, and parameters, it can either precede or parallel the following steps.

(2) Description of Actions - those actions which must be represented must be described so that code to implement them can be written. They need not be associated yet with the conditions that require them.

(3) Description of Situation - the inputs to the BGS must be described so that code to recognize these conditions can be sritten.

(4) State Assignment - a set of operations which will describe the various modes of operation of the entities must be described. These will correspond to the states. The rules for state transitions then must be described in terms of the situation description of 3 above. These rules must also include the pushing and popping of the stack.

(5) Output Definition - the outputs associated with the various states or transitions must be described in terms of the output parameters and actions, and the required inputs to drive them.

(6) Input Table Construction - a table can then be constructed to translate the situation aspects into the codes necessary to define all of the state transitions and outputs.

(7) State and Output Table Construction -these tables can be defined given the inputs and the results of steps 4 and 5 above. This completes the BGS design.

4. <u>Proposed Brigade/Regiment Behavior Generation System Characteristics</u>

The following are the operation codes and actions planned for the INWARS implementation:

a. Operation Codes

(1) Prepared Defense: used when a unit has been in place in a hasty defense for a specified time

(2) Hasty Defense: basic defensive posture

(3) Delay: used to trade space for time; decreases attrition rate

(4) Withdraw: used by units to break contact, or initiated by the BGS due to loss of effectiveness

(5) Main Attack: Basic attack posture; corresponds to Soviet hasty attack

(6) Secondary Attack: This attack operation results in lower attrition rates and less chance of success than above

(7) Breakthrough: This operation allows considerable massing and high attrition rates at some cost in attacks vulnerability

(8) March: used for non combat movement

(9) Reserve/Assembly: a basically defensive posture which allows quick employment and avoids contact

b. Action Codes

(1) Generation of a new objective: this causes a unit to consider changing its objective. The action gives a distance, either ahead or behind the unit, for the new objective. The hex at that distance along the unit's axis of operation then may become the new objective. If the distance is only one hex, however, the actual objective will be chosen using the movement scoring mechanism. The objective of a unit is changed only if the unit is not already moving on a path within 60o of the direction to the desired direction.

(2) Call for artillery support: This action specifies a level of GS artillery support desired from division assets.

(3) Call for close air support or attack helos: similar to artillery, but these requests are simply relayed to Corps by the division

(4) Call for reinforcement: This action influences the division's assessment of the situation, and may cause planning, the release of reserces, or the shifting of assets from one entity to another.

(5) Report of critical situation: This action will initiate a message to Corps.

(6) Push stack: This flag will cause the previous situation to be saved on the stack, along with information on the conditions under which it should be restored.

(7) Pop Stack: If there are states saved on the stack, the top one will be restored as the state, or operation, of the BGS.

c. Example:

Figures IV-4 through IV-8 illustrate a preliminary example of how the Behavior Generation System might be implemented in INWARS for Brigades and Regiments. This example is for illustration only. The data and format of the tables will be revised and developed in accordance with the process described in b. above. Figure IV-9 illustrates this example.

A unit initially is at its assigned objective, and is in a hasty defense operation. If has suffered no significant casualties, and has an effectiveness degradation state of 0, indicating no impairment. No further operations are in the unit's operation stack awaiting execution.

(1) Time step 1: During the unit's perception process, enemy units are found in adjacent hexes, but do not present a flanking threat. The situation code table (Figure IV-4) is used to find the appropriate situation code, 16, for the situation of not being in danger of being flanked, adjacent to enemy units, not

NUCLEAR VICTIM	AT OBJECTIVE	EFFECTIVENESS DEGRADATION	NOT IN DANGER				IN DANGER		
			nc	adj	hex	mtg	adj	hex	mtg
no	no	0	1	2	3	4	5	6	7
no	no	1	1	8	9	10	11	9	10
-	no	2	12	13	14	14	14	14	14
no	yes	0	15	16	3	4	17	6	7
no	yes	1	15	18	9	10	19	9	10
-	yes	2	20	13	14	14	14	14	14
yes	no	0	21	22	9	10	23	9	10
yes	no	1	21	24	14	14	25	14	14
yes	yes	0	26	27	9	10	28	9	10
yes	yes	1	26	29	14	14	20	14	14

Figure IV-4. Situation Code Table

OPERATION	ACTIONS SITUATION (3 rows for 0-9, 10-19, 20-29 respectively) 0	1	2	3	4	5	6	7	8	9
1. Prepared Defense	0	17	5	8	8	9	9	8	9	2
	2	0	17	2	3	4	12	9	12	9
	4	14	15	16	16	16	14	16	16	16
2. Hasty Defense	0	17	5	8	2	1	2	2	9	2
	2	1	17	2	3	4	12	1	12	2
	4	14	15	16	16	2	14	16	2	2
3. Delay	0	17	5	10	2	10	10	2	9	2
	3	9	17	2	3	4	12	1	12	2
	4	14	15	16	2	2	14	16	2	2
4. Withdraw	0	17	5	9	11	10	10	11	9	3
	3	9	17	11	3	4	1	1	11	11
	4	13	3	3	3	3	13	11	11	11
5. Hasty Attack	0	17	5	8	8	5	8	8	11	11
	11	11	17	5	3	4	12	12	12	12
	4	13	15	15	16	16	13	15	15	16
6. Coordinated Attack	0	17	5	8	8	5	8	8	11	11
	11	11	17	5	3	4	12	12	12	12
	4	13	15	15	16	16	13	15	15	16
7. Break-through	0	17	8	8	8	8	8	8	11	11
	11	11	17	5	3	4	12	12	12	12
	4	13	15	15	16	16	13	15	15	16
8. Recon	0	17	8	8	8	8	8	8	11	11
	11	11	17	5	3	4	12	12	12	12
	4	13	15	15	16	16	13	15	15	16
9. March	0	0	4	18	18	12	18	18	12	18
	18	12	0	18	18	4	12	12	12	12
	4	13	2	2	2	2	13	2	2	2

Figure IV-5. Action Table

action code	push	pop	gen obj fwd	gen obj back	consider move	arty req	air req	reinf req	send msg
0									
1	X			1		1	1		
2	X			1		2	2	1	1
3				1		3	3	3	1
4		X							
5							1		
6					X	1	1		
7			1						
8						1	1		
9						2	2	1	
10				1		1	1		
11				1		2	2	1	1
12		X				1	1		
13	X								1
14									1
15						1	1		1
16						2	2	1	1
17	X								
18		X		1		2	2		1

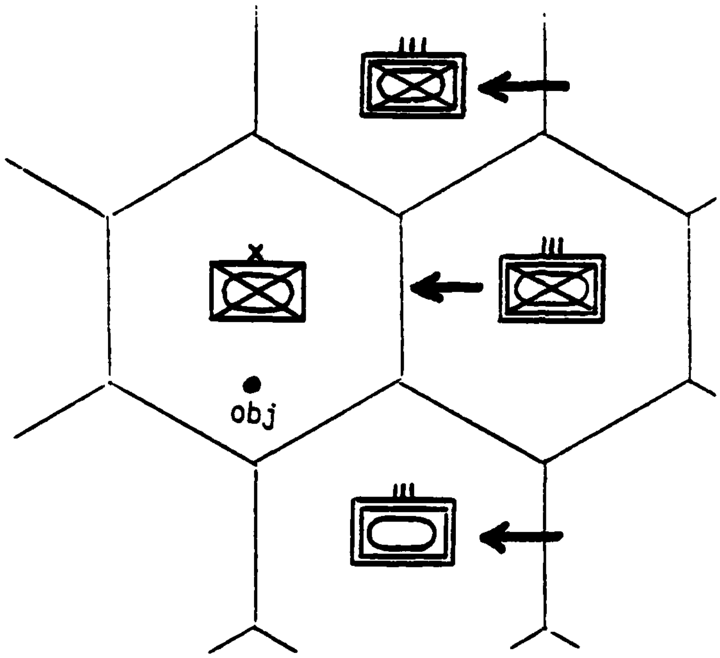
Figure IV-6. Action Code Table

OPERATION	SITUATION CODE (3 rows for 0-9, 10-19, 20-29)									
	0	1	2	3	4	5	6	7	8	9
1. Prepared Defense		9			5			5		3
	5		9	3	4					
2. Hasty Defense		9			5		3	5		3
	5		9	3	4					3
					3	3		3	3	3
3. Delay		9			5			5		
	5		9		4	2	2		2	
	2									
4. Withdraw		9			5	2	2	5		
	5		9			2			2	
	2									
5. Hasty Attack										
					4					
		2						2		
6. Coordinated Attack										
					4					
		2						2		
7. Breakthrough										
					4					
		2						2		
8. Recon										
					4					
		2						2		
9. March			2	5	5	2	5	5	2	5
	5	2		2	4	2	2	3	2	4
	2	2	2	3	2	3	2	2	3	3

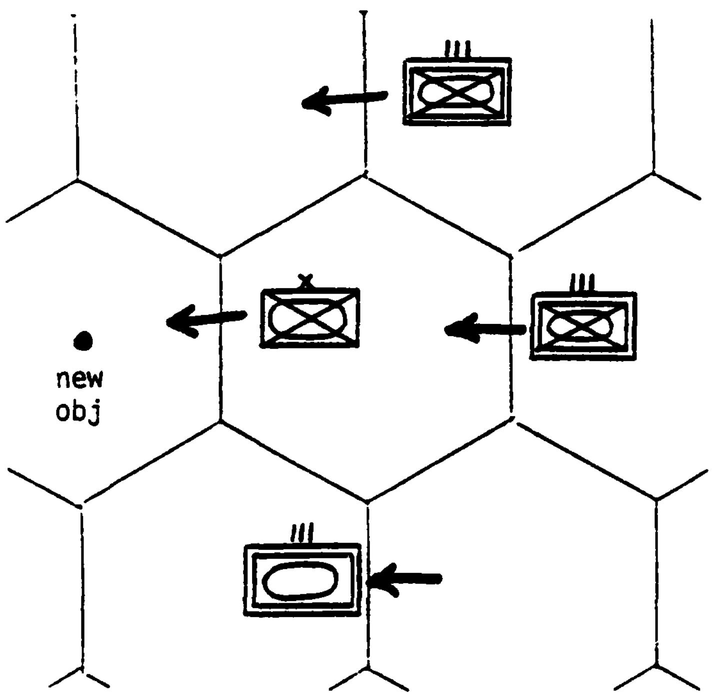
Figure IV-7. Operation Behavior Table

OPERATION	SITUATION CODE (3 rows for 0-9, 10-19, 20-29)									
	0	1	2	3	4	5	6	7	8	9
1. Prepared Defense		9								3
	3		9	3	4					
2. Hasty Defense		9			3		3	3		3
	3		9	3	4			3		3
					3	3			3	3
3. Delay		9								
			9		4	2	2		2	
	2									
4. Withdraw		9				2	2	3		
			9			2			2	
	2									
5. Hasty Attack										
					4					
		2						2		
6. Coordi-nated Attack										
					4					
		2						2		
7. Break-through										
					4					
		2						2		
8. Recon										
					4					
		2						2		
9. March			2	2	2	3	3	3	2	4
	4	3		4	4	2	2	3	2	3
	2	2	2	3	2	3	2	2	3	2

Figure IV-8. Operation Transition Table

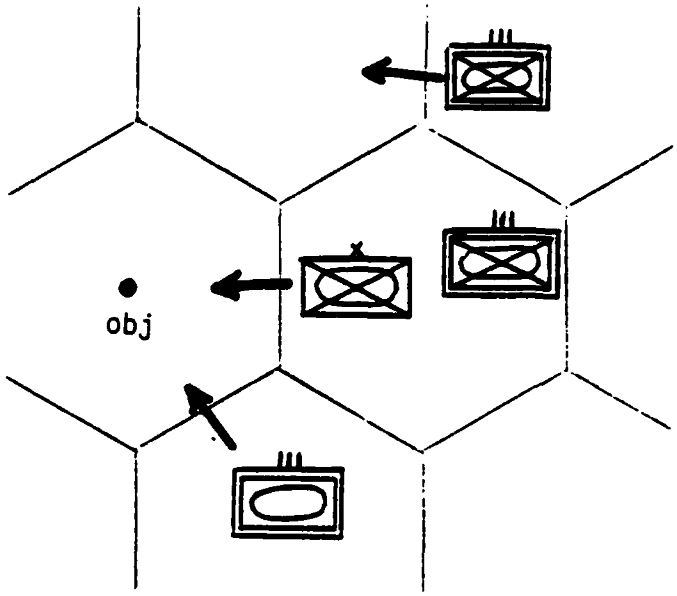


Situation = 16
Artillery req = 1
Air req = 1
stays in hasty defense
stack empty

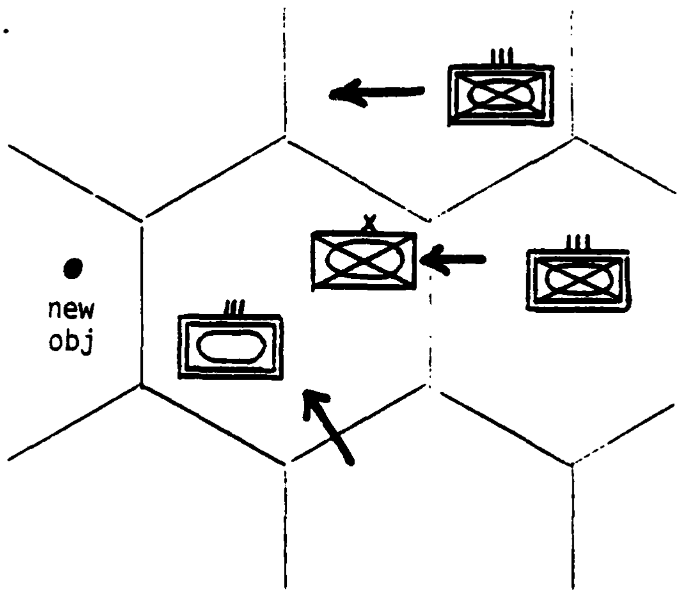


Situation = 17
Artillery req = 1
Air req = 1
generates objective
one hex to rear
stack: saves
Hasty Defense

Figure IV-9a. Example of Behavior Generation System Operation, Time Steps 1 and 2

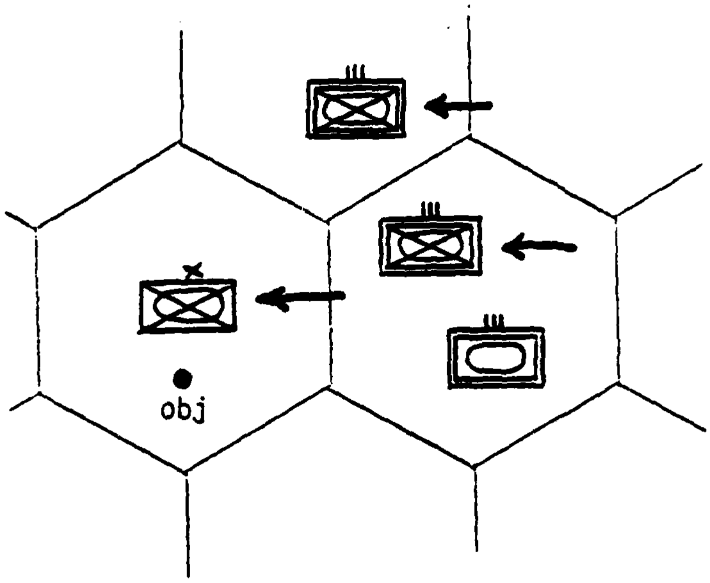


Situation = 6
Artillery req = 1
Air req = 1
moving to new objective
stack: Hasty Defense



Situation = 10
(meeting
engagement)
Artillery req = 3
Air req = 3
Reinforcement requested
generates objective
one hex to rear
stack: Hasty Defense

Figure IV-9b. Example of Behavior Generation System Operation, Time Steps 3 and 4



Situation = 18
Artillery req = 1
Air req = 1
Hasty Defense
popped from stack

Figure IV-9c. Example of Behavior Generation System Operation, Time Step 5

being an immediate chemical or nuclear victim, at the unit's objective, and having no degradation of effectiveness. The action table (Figure IV-5) is then entered for the situation code 16 and the operation code of 2 for Hasty Defense; an action code of 12 is found. The action code table (Figure IV-6) indicates a low priority request is made for air and artillery support to take advantage of the targets presented. The pop operation stack flag is ignored since no further orders are in the stack. The Operation Behavior Table (Figure IV-7) is also entered with the operation code of 2 for Hasty Defense and the situation code of 16. A blank entry (zero in the software implementation) indicates the unit will behave normally in a hasty defense. The Operation Transition Table (Figure IV-8), entered for Hasty Defense and situation code 16 indicates no change.

(2) Time step 2: Since the previous interval an enemy unit has moved into a position to threaten the unit's flank. The situation code of 17 results. The action table yields a code of 1, which indicates the operation stack is to be pushed, saving the hasty defense operation. The unit will also generate an objective one hex back, so that movement will now be toward that objective. The hex will be chosen on a basis of various threat, cover, cohesiveness, etc. considerations discussed in Chapter V section E. Requests are made for air and artillery support. The operation behavior and transition tables indicate an operation code of 3, indicating the unit is now delaying back the one hex to the new objective.

(3) Time step 3: At this time one enemy unit has attacked into the same hex. The unit has not yet withdrawn out of the hex back to its new objective, and remains in danger, resulting in a situation code of 6. For the Delay operation, action code 10 is found indicating artillery and air requests and the generation of a new objective. The latter action is ignored since the unit

is already moving in an appropriate direction. Blanks in the Operation Behavior and Transition tables indicate continuation of the Delay operation.

(4) Time step 4: The unit has now arrived at its objective hex, but the flanking enemy unit has also moved into that same hex resulting in a meeting engagement. The resulting attrition has increased the unit's effectiveness degradation level to 1, meaning it is now marginally effective. The situation code of 10 and operation code of 3 yield an action code of 3, which indicates high priority air support and artillery requests, and calls for reinforcement. A special situation message to Corps is also called for. A new objective one hex further to the rear is generated. The operation behavior table gives a code of 5, indicating a hasty attack posture for the meeting engagement condition, although the operation transition table indicates a continuation of the delay operation.

(5) Time step 5: The unit has withdrawn from the hex in which the meeting engagement took place, and has now reached its objective. No enemy units are in the hex or present a flanking threat. Effectiveness degradation is still at level 1. Situation code 18 is found; action code 12 results from that and the delay operation status. Artillery and air support are requested, and a stack pop is made, restoring the unit's original operation code of hasty defense. The behavior output code is 2, or hasty defense, and the operation transition result is ignored since the stack supplied the next operation code.

5. <u>Conclusion</u>

The BGS can be applied to the modeling of the conduct of operations, allowing significant savings in software development effort and enhancing ralistic treatment of a unit's actions. In addition, changes or additions to the set of operations or their transitions can be accomplished by changing the data in tables rather than by modification of the code. This makes the combat process more accessible to the user

and reduces the cost of implementing changes to represent new doctrine or tactics. Another aspect of this structure is that the implementation of complex plans generated by the C2I software can be implemented by passing a unit a new stack of operations to be executed. This allows significant simplification of the software.

C. APPLICATION OF THE BEHAVIOR GENERATION SYSTEM TO DIVISION PROCESSES

The Behavior Generation System can be applied to the operation of the divisions as well as the maneuver elements by making the following adaptations:

(1) Inputs - The divisions must consider more factors than the smaller entities. The development of these factors was previously discussed in Section III B. In addition, a composite measure of effectiveness is needed. The size of the situation table can be reduced by combining some elements before the table look up step.

(2) Actions - in addition to the simple actions performed by the entities, division must be capable of allocating divisional GS artillery support, initiating reinforcement from reserves, and reallocating forces. Most important, the divisions must be capable of planning a position or objectives for their subordinate units, and issuing the necessary orders.

(3) Input of Plans from Corps - when CORPS develops a plan for an attack, it will pass a stack of operation orders to the divisions which will attempt the execution of various types of attacks, defense, etc. The actual planning at the division level is accomplished as each operation requiring planning is popped from the stack as the sequence of objectives or phases are reached.

1. Division Operations

The following is a preliminary list of division operation codes:

(1) Defense: This is the basic operation type for divisions in a defensive posture, it assumes the division will maintain a cohesive position within a given region

(2) Delay: This is like the defense except that individual regiments or brigades will make tactical withdrawals if faced with large force ratios, and will attempt to trade time for space.

(3) Main Attack: This is the basic attacking posture; usually will employ available forces in two echelons in a fairly narrow sector.

(4) Secondary Attack: This form of attack will employ a smaller proportion at the division in reserve, and will normally use a larger sector width. Brigades or Regiments will use the corresponding operation code to minimize losses

(5) Breakthrough: This attack operation is used to achieve maximum concentration

(6) Reserve: This is used for divisions which are uncommitted.

2. Actions

These actions can be initiated by divisions:

(1) Generation of a New Objective: This generally corresponds to the same action of the brigades, except that objectives are described in terms of regions rather than hexes. An objective region will be a center hex, an axis of orientation, and a sector width. Generated objectives will usually adjoin or overlap previous ones.

(2) Call for artillery support or attack helos: The division may request additional allocation of artillery or attack helicopters from Corps

(3) Call for close air support: In addition to the requests from individual brigades or regiments, the division can add weight to the priority requested.

(4) Call for reinforcement: This initiates a message to Corps requesting additional ground combat assets

(5) Report initiation: This generates a situation report to Corps.

(6) Push and Pop operations: These directly correspond to similar actions of the brigade/regimental BGS.

(7) Reserve Commitment: This action specifies the commitment of a specified force from divisional reserves or second echelon.

(8) Force shift: This is the shifting of assets from a less threatened area to a more threatened area.

(9) Change Axis: The division's axis of operations may be charged, particularly in those cases where strong flanking forces exist.

(10) Plan: This flag initiates the planning process which is dealt with in the next section.

3. Planning

At some stage in the planning process generally defined regions must be translated into particular hex objectives for particular units. This is done in the division planning process. There is no attempt to incorporate phases or more complex aspects such as the CORPS does in INWARS basic. The planning process takes place in three steps:

a. Position Definition

In this step the division chooses a series of hexes for objectives within the region. For defensive operations they are chosen to span the sector width with no gaps. For offensive operations they will be chosen around the center of the region with an emphasis on key terrain. It may also be desirable to use template type assignments for certain cases, such as assembly areas in preparation for an attack.

b. Unit Assignment

The units are assigned to particular objectives. Combinations which are feasable are scored, and the units assigned to hex objectives and given appropriate sector widths in accordance with the best combination.

c. Order Implementation

The orders appropriate for the units are attached to them. During the scoring of unit assignments, estimates for time to perform the mission or capability may be developed which could be passed to CORPS. This may be more appropriate for later phases of INWARS.

CHAPTER V
MOVEMENT

A. INTRODUCTION

The fixed time interval, or fixed Δt movement mechanism for INWARS was chosen for its ability to complement the combat resolution method, and for its simplicity and low processing overhead, compared with alternative methods.

B. MOVEMENT METHOD ALTERNATIVES

Application of simulations to digital machines require that various parameters be quantized. In INWARS the use of a 9.5 km resolution is implicit in the choice of that size hexagon as a fundamental quantum of area. Continuous processes must also be quantized in their effects by aggregating them into discrete events. A Δt must be chosen so that the implications of the event do not differ unduly from the continuous process being represented.

Movement is a process which occurs in both the time and space domains, and thus both must be quantized. Simplicity may be achieved by fixing either the time interval, Δt, or the space or distance interval, Δx, and allow speed to be represented by a variable x or t respectively. The choice of method carries a number of implications, which are summarized below:

(1) Fixed Δx - This choice for movement implies that units move from one location (hex) to another, a fixed distance, during a variable time interval chosen to give the correct overall speed. This allows movement to be represented as a scheduled event, occurring with a frequency proportional to unit speed, and only one cycle of movement consideration, selection, and scheduling need be done per hex moved. This also implies that the unit remains in a particular hex until its scheduled arrival, at which time it

'jumps' to the next hex; there is no implicit information about how far a unit has moved between hexes until arrival. A disadvantage of this method is that perterbations in a unit's speed cannot easily be reflected. The speed is determined at the time of scheduling, and events occurring between scheduling and arrival can have no speed effect unless the arrival is cancelled and a new one scheduled for a different time. As perterbations in speed become smaller and more frequent, the problem gets much worse, particularly as scheduling and cancellation of events causes use of a significant amount of software for processing. Other problems occur in resolving the case when a unit changes direction or stops. The latter case requires either a movement to the same hex, or a "no move scheduled" condition, which has possible negative implications in controlling the next move.

(2) Fixed Δt - This choice implies that units move at fixed intervals, and thus the distance moved must either be large compared to the space resolution or that some method of resolving small increments of movement lower than the hex diameter be used. The latter choice is clearly required for INWARS, since large moves of many hexes cannot easily be integrated into the combat movement scheme. At fixed intervals all units would be moved some distance, with movement from one hex to another accomplished when the distance moved from the center of the last hex is greater than one hex radius. This method requires that movement be accomplished at more frequent intervals than the fixed Δx method, although the decrease in time required to schedule individual units should more than offset this. The space requirement for detailed location information should be less than that consumed by the scheduling process. Another advantage is that, since movement is accomplished at each interval, speed perterbations can be accomplished more easily, either by modifying the speed for one or more intervals, or by superimposing another

speed vector by actually moving the unit backward to account for delays. This method also appears to offer an increase in resolution. This is deceptive, however, since the increase in resolution in movement between hexes is not matched by an increase in angular resolution. The increase in resolution of a particular location is limited to the size of a hex face, or 1/2 the value with the previous method. Even this, however, is not a useful benefit since distance traveled between points 1/2 a hex diameter apart can be up to one hex unit, or 9.5 Km.

(3) Combinations - unfixed or partially fixed Δx or Δt - it is possible to mitigate the deficiencies of the fixed Δx representation by adding features such as repeated scheduling, delay after arrival characteristics to account for lost speed, or scheduling arrival at hex sides and then scheduling a subsequent arrival at the next hex center. In making these changes, however, much of the simplicity of the initial fixed interval assumption is lost.

C. CHOICE OF FIXED Δt MECHANISM

The fixed Δt movement method will be used in the INWARS model for the following reasons:

(1) Space - in INWARS, memory space is limited. If each of the approximately 1000 possible units is to be scheduled for movement independently, a significant amount of space is consumed for scheduled events, pointers to them, etc. In addition, if situation assessments are to be stored, a large amount of space is consumed. This need can be eliminated by performing movement and combat following the same situation assessment process, which requires either fixed Δt movement or synchronization of combat to movement, with the former being preferred.

(2) Time - it is expected that the time step for combat in INWARS will be on the order of 15 minutes. Moving at 30 km/hr, the maximum expected, units can travel less than one hex per interval, so that synchronization of movement to combat will not require a multi-hex jump.

In CLEW the most time consuming and complex part of the movement process was that associated with choosing a direction and moving a unit from one hex to another. This need not be repeated more often due to the change in method, since during most intervals only an incremental movement is made, which would be a much simpler process. At the same time, savings could be made due to the elimination of, scheduling movements, perceptions, and reactions as was done in CLEW.

D. MOVEMENT SPEED

Movement speed will be based on a unit's operation type, and modified to account for terrain, enemy presence, attrition, and nuclear/chemical readiness. The formula below will be used:

$$Sp = Sp_{\sigma} (1-t_{\theta}T_{s}) (1-r_{0}R_{s}) (em) (1-w_{0}w_{s})$$

Sp_{θ} = normal movement rate for the particular operation

t_{θ} = terrain effect factor operation modification; indicates to what extent terrain may slow movement

T_{s} = terrain effect on speed for type A, B, C, D as appropriate

r_{0} = river effect factor operation modification; indicates to what extent rivers may slow movement

R_{S} = river effect on speed (0 for no river)

em = effects of enemy mass

w_{σ} = weather/darkness operation modifier

w_{s} = the effect of the current weather/darkness status

The distinction between combat and non combat movement will be implicit in the operation of the BGS; units not in combat

will normally transition to march operation codes when not at their objectives, which will cause them to move faster.

E. MOVEMENT DIRECTION

When a unit arrives at the center of a hex it must determine its next direction. It does this by scoring each of the six possible directions and the non move, and choosing the direction receiving the highest score. The weighting factors in the scoring formula depend on the operation code, enabling it to influence the behavior of the unit. While the exact form of the scoring equation will be the subject of experimentation during the test and evaluation phase, the formula used in CLEW can be adapted as a working prototype. The following terms will be included:

(1) Direction to the Objective - this term will be in the form

$$Vd = Do \cos \theta$$

Vd = the value of the direction component of the score

Do = the weight for directionality assigned for the operation

θ = the angle between the direction to the objective and the prospective direction which is being scored

(2) Maximum massing

Vm = Maximum $(0, M-Mo)$

Vm = the value of the massing component of the score

M = the expected massing value which will occur if the move is made

Mo = the massing value desired for the operation

(3) Enemy Threat

$Ve = -Eo\ e$

Ve = the enemy threat component of the score

Eo = the enemy threat reaction for the particular operation

e = evaluation of the expected enemy threat for the particular direction

(4) Speed

$Vs = So \quad Sp$

Vs = the speed component of the score

So = the weighting value for speed for the particular operation

Sp = the speed obtainable in the direction scored

(5) Cover

$Vc = Co \quad (L1-C)$

Vc = the cover component of the movement score

Co = the weight given cover for the operation

C = the cover factor for the next hex in the scored direction

(6) Cohesiveness

$Vch = Ch\ (\max(F_L \sin \emptyset_L) + \max\ (F_R \sin \emptyset_R\ ))$

Vch = the cohesiveness component of the movement score

Ch = the weight given cohesiveness for the operation

L = an index for friendly units within one hex on the left of the unit's axis of operations

F_L = a value assigned to the friendly unit; it will be 1 for most units but 2 for a friendly unit of the same division

$\emptyset_L$ = the angle from the axis of operation to friendly unit L

R, F_R, and $\emptyset_R$ correspond to L, F , and $\emptyset$ for units on the right

The form of this factor could vary due to implementation considerations and as a result of test and evaluation.

CHAPTER VI
ATTRITION

Attrition in an aggregated unit model can be modeled from one of two very different points of view. In one, a model is constructed which attempts to accurately reflect the actual processes taking place. This would use data parameters for firing rates, probability of kill, terrain effects, etc., which have physical significance or are measurable. The other approach uses a simpler mechanism, and fits results to what appears "reasonable" or to what may result from another model. In this approach, parameters often do not directly relate to physical data, since the requirements of tuning weaken this link. The latter approach is used in INWARS in accordance with the simulation specifications. Toward that end a simple Lanchester Square Law type mechanism is used for attrition processes, adapted to handle multiple weapon target types and multiple unit engagements.

A. INTRODUCTION

In INWARS attrition will be a process which occurs at fixed intervals between entities. The interval size will be a user input chosen "small" relative to the possible interactions among entities. At each interval a given entity will engage enemy units which are in the same hex. Certain entities such as artillery will also engage other targets under some circumstances. The employment of nuclear and chemical weapons will be treated distinctly, and the attrition mechanisms discussed in most of this chapter will be for conventional weapons.

B. WEAPON AND TARGET CHARACTERISTICS

Each type of conventional ground force weapon in INWARS will be represented by a weapon code and a corresponding entry in the weapons effects table, which describes the characteristics of the weapon as

illustrated in Figure VI-1. Targets which are not weapons are similarily represented, but have no attrition inflicting capability. The entries in this table are described below:

(1) Weapon Type - This is a number which serves to identify a particular weapon, and the name of the weapon it identifies (for output purposes only)

(2) Target Class - Each weapon or target will be classified as either hard, medium, or soft, artillery, or air. Examples for each of the first three classes would be the M60 tank, BMP, and DRAGON respectively.

(3) Marginal Vulnerability - This factor allows particular weapons/ targets to be made more or less vulnerable than others of the class. One might assign a number larger than the normal value of one to a tank with particularly effective protection. A value of one will be used for all weapons initially except in those cases where data can be provided showing a particular target has more protection or is less vulnerable.

(4) Nuclear/Chemical Readiness Degradation - This is a factor which describes the degradation in weapon effectiveness due to a nuclear or chemical readiness posture. This may be further modified for all weapons in a unit to reflect the degree of readiness or severity of the environment.

(5) Kill Rates vs Hard, Medium, Soft Targets, Artillery and Air - These are kill rates against the respective classes of targets for the particular weapon.

(6) Target Dependency - If the weapon or target is not an independent target, this is the number of another weapon/target to which its attrition is linked. Independent targets are indicated by a zero. The degree of dependency is also represented. This implements the provisions for asset classes described in Chapter II E (3) and (4).

(7) Range - This gives the range of the weapon in number of 9.5 km hexes. It will be zero for direct fire weapons, indicating a

INWARS

WEAPONS EFFECTS TABLE

Type	Class	Vuln.	N C	K_H	K_M	K_S	K_A	K_V	...
1	H								
2	M								

Type = weapon type

Class = target class

Vuln = vulnerability relative to other targets in same class

N C = nucl/chem readiness performance degradation

K_H = kill rate vs hard targets

K_M = kill rate vs medium targets

K_S = kill rate vs soft targets

K_A = kill rate vs artillery targets

K_V = kill rate vs aircraft/helos

Figure VI-1. Weapons Effects Table

capability to engage only those targets in the same hex. It will be larger for artillery. No range considerations other than this shoot/no shoot capability will be represented.

(8) Special Processing - If the weapon or target is involved in a special process which takes place at regular intervals, a code is inserted here. An example where this might be done is the consumption of supplies, the implementation of special speed or suppression effects, etc. This feature will probably not be used in INWARS basic.

(9) Allocation Value: This is a value used as a weight in the allocation process for distributing fire.

(10) Other Attrition Effects - In the second phase of INWARS, the possible need for a more sophisticated attrition modeling may require a more detailed description of the weapons. Such factors as target saturation effects, mobility of fire or range, and others could be added to the table.

C. ARTILLERY TARGETING

For direct fire weapons, targeting will simply be that the weapon engages all enemy targets in the same hex. The artillery targeting process is more complex. Artillery can be divided into two types, with the assets attached to individual brigades and regiments considered in a Direct Support role and that attached to Division's being in a General Support role.

1. Direct Support Artillery - the artillery at the brigade/regimental level will be used as other weapons, except that it can also engage targets in adjacent hexes. The allocation of fire to individual enemy units will, like for direct fire weapons, be on a basis of threat.

2. General Support Artillery - the general support artillery attached to the divisions can engage targets from two sources, those assigned from Corps and those requested by the brigades or regiments.

a. Corps supplied targets - one action a corps may initiate is a message to a particular division giving it a target list. This list contains enemy units to be targeted, an allocation factor, a timer for the length of time the target is to be engaged, and a description of the type of engagement, i.e. nuclear, conventional, etc.

b. Targets supplied by Brigades/Regiments - one of the actions a brigade or regiment can initiate is a request for GS artillery, giving an amount requested.

c. Target Engagement - all of the targets supplied by CORPS are engaged, with the allocation to each target determined from the list. If the allocations exceed the weapons available, they are reduced proportionally. If any excess exists after servicing the CORPS target list, it is used to engage targets as requested by the brigades, with allocations made on the basis of the amount requested and the threat of each enemy unit. No targets may be engaged which are beyond the range of the artillery; that target is not allocated any fire. If it was a target assigned from CORPS, a message could be initiated.

D. CONVENTIONAL ATTRITION MECHANISM

For INWARS basic a Lanchester Square Law mechanism will be used, which allows the attrition to be computed from the number of firing weapons and their characteristics. This method was chosen principally due to the availability of data. Other more detailed attrition mechanisms may be considered for later implementation in the refinement phase of INWARS based on test and experimentation.

1. Attrition Formula

$$\Delta X_i = \sum_{\forall j} \alpha \, . \, Y_j \, . \, k_j(_i) \, . \, V_i \, . \, T \, . \, N \, . \, Op \, . \, t$$

ΔX_i = The attrition on target type i of the target unit

α = Allocation factor; distributes firing unit's fire among enemy units and weapons on a basis of threat or target value

Y_j = The number of firing weapons of type j

$K_j(i)$ = The kill rate of type j weapon agains the target class of i

y_i = The marginal vulnerability of target type i

T = The terrain and environment effects

N = The firing weapon's effectiveness degradation due to the nuclear/chamical warfare environment

Op = The combined effects for the operation combination of the firing and target units.

t = A tuning factor to adjust attrition as desired.

2. Operational Effects

The operation codes of the firing and target units significantly affect the attrition process in a number of different ways. Most directly, the factor Op is taken from a matrix of operation code combinations. Indirectly, factors dependent on the operation code vary the effects of T and N.

3. Allocation

Some means of allocating a weapon's fire among various targets must be used. For INWARS basic, this will be done on a basis of the target value of the weapon or target being fired on. This number will be one for most cases, except where the firing weapon would deliberately avoid some targets in favor of others.

4. Data

The basic kill rates used in INWARS are analogous to those in CEM-IV. It appears that a small conversion routine could be used to derive the values needed for INWARS. Data not available from CEM-IV will be derived from other sources or estimated as required.

5. Possible Improvements Which May Be Required in Phase 2

In the refinement phase the following modifications to the attrition process may be considered, as the simple process described above may distort the combat results and, as a result, the decision processes. It is necessary to provide the flexibility to allow these improvements.

(1) Linear Law Attrition Effects - The Lanchester 'linear' attrition mechanism, unlike the 'square law' proposed for INWARS basic, makes attrition proportional to the number of surviving targets. This refelects an emphasis on the necessity of finding targets, and a dominance of the attrition by this process rather than the mechanics of firing at targets, if it is presumed that target acquisition is proportional to the number of targets. The actual mechanism appropriate varies for different weapons, operations, and terrain. An attrition mechanism of the form

$$\Delta X = k y \frac{X}{X+b}$$

or some other form combining linear and square effects would allow more realistic treatment of attrition, and perhaps extend the usefulness of the model.

(2) Force in Contact Effects - The basic Lanchester attrition mechanisms assume the entire force on both sides is available as targets or to fire. In large units such as the entities in INWARS, where range is small compared to the area occupied by the units, a significant portion of the force is not engaged due to being kept in reserve, variances in position, or inefficiencies resulting from dispersion due to nuclear precautions. These effects are cascaded among multiple echelons, and become more pronounced in aggregated units. A mechanism to account for these effects may be added.

(3) Implementation of Attrition Effects - Changes in the form of the attrition mechanims do not change the body of the software supporting them; any changes made as a result of the test and evaluation phase will cause a minimum of change in code, provided the structures and software are designed for flexibility. The computation time for the actual attrition calculations should prove very small compared to the remainder of INWARS, so more complex mechanisms would have little effect. The major consideration is the acquisition of supporting data.

E. NUCLEAR ATTRITION MECHANISM

Attrition due to the detonation of nuclear devices in INWARS will be scheduled events, rather than time stepped as is conventional ground attrition. The only exception would be in the case of nuclear missions fired by divisional GS artillery. When such an event occurs, the attrition process will be carried for the particular type and number of nuclear device and the target unit as follows:

1. Attrition Formula

The nuclear attrition will be computed using the same basic form as conventional, although the parameters will differ:

$$\Delta X_i = Y_j(i) . T . N . Opn. tn$$

ΔX_i = The attrition on target type i

= Allocation factor; the proportion of targets of type i

Y_j = The number of nuclear devices of type j

$K_j(i)$ = The normalized number of kills inflicted by nuclear device type j against the target type of i

T = The terrain/weather/environment effects

N = The effects of the target's nuclear readiness

Opn = The effects of the target's operational status on nuclear attrition

tn = tunning factor for nuclear effects

2. Operational and Environmental Effects

Operational effects would be principally the increase or decrease of the unit's vulnerability due to concentration required for the particular type of operation, and the availability and use of covered positions. Environmental effects would include the effects of cover and visibility, but might be small enough to neglect.

3. Improvements Which May Be Required in Phase II

More detailed and accurate nuclear attrition mechanisms may be developed in the refinement phase of INWARS, and could take into account nonlinear effects of employing multiple weapons, the "linear law" effects of the area occupied by the unit, and others, if this is required to accurately drive the C2I processes.

4. Residual Effects

After a nuclear detonation, particularly ground bursts, a significant area of terrain may be contaminated. This would make the hex somewhat less desirable to occupy, and could be considered in movement.

5. Dose

It is possible to keep track of accumulated average dose for various units, but this would not be considered for INWARS basic.

6. Collateral Casualties

When each detonation occurs a computation would be made for civilian casualties, based on the terrain type.

F. CHEMICAL ATTACK ATTRITION

Chemical attack in INWARS basic would be treated in much the same manner as nuclear attrition. In the case of persistent agents, contamination similar to the residual nuclear effects could be incorporated into the

terrain. The same attrition equation form as in E above would be used, except that the parameters would be those derived for chemical processes.

CHAPTER VII
INWARS UNIT RECONSTITUTION AND REPLACEMENT

As units suffer attrition, their effectiveness is degraded and their reactions to situations changed. The personnel and equipment casualties have effects beyond the proportional loss of firepower. If a unit which has suffered attrition is withdrawn, it may be reformed into an effective force again by adding replacements, attaching new replacement organizations, by internal reorganization, or by a combination of these processes. This reconstitution mechanism which will reflect these effects.

A. EFFECTIVENESS

1. Computation of % Effectiveness

A unit's effectiveness is dependent on many factors, one of the most important being equipment and personnel casualties. In INWARS, effectiveness will be a function of a casualty level, expressed in % strength. Each asset in the unit's asset list has a *weighting factor used* to determine its contribution to the overall effectiveness of the unit. For each asset, a % strength is determined by comparing present strength to a base strength. These contributions to % effectiveness will then be combined with effectiveness contributions weighted with the asset's weighting factor. The formula used is:

$$\%E = \sum_{\forall i} W_i\,(b_i - X_i) \Big/ \sum_{\forall i} W_i$$

$\%E$ = percent effectiveness of unit

i = index for assets in list

W_i = Weight for contribution of asset i to unit's effectiveness

b_i = base strength for asset type i

X_i = actual strength of asset type i

Note that this effectiveness rating is not an input to the attrition equation, but instead affects behavior.

2. Effectiveness States

The % strength value will determine which of three distinct effectiveness states a unit is in. This state is used as an input to the Behavior Generation System described in Chapter IV. The level at which the states occur are dependent on the operation code of the unit.

(1) State 0 - No loss in effectiveness: a unit in this state behaves normally. Casualties suffered cause only their proportional loss in total unit firepower.

(2) State 1 - Marginally Effective: units in this state are not fully capable, and their ability to attack and defend is severely degraded. For example, defending units under attack will delay rather than hold ground in many situations, while attacking units will be limited to a holding attack.

(3) State 3 - Ineffective: A unit in this category is ineffective and will seek to break contact from enemy units and withdraw.

B. RECONSTITUTION BY REORGANIZATION

In this section the effect of reconstitution by reorganization alone will be developed. A unit starting such a process enters with a strength significantly smaller than his base, or original, strength. At the end of the process, he is reconstituted as a smaller; but effective, organization. This implies that the base strength and present strength are about equal. At that point the reconstituted unit is as effective as it was before the attrition was suffered, albeit with proportionally less firepower. Figure VII-1 gives a simplified example.

1. The Reconstitution Environment

A unit can reconstitute only if it is free to consider reorganization as its major activity. This implies that it cannot be engaged in an attack, major road movement, or actively defending. For CLEW the criteria used was that the unit was not engaged in combat, and was in a defensive/ assembly area posture. This should suffice for INWARS, after making allowances for nuclear or chemical contingencies.

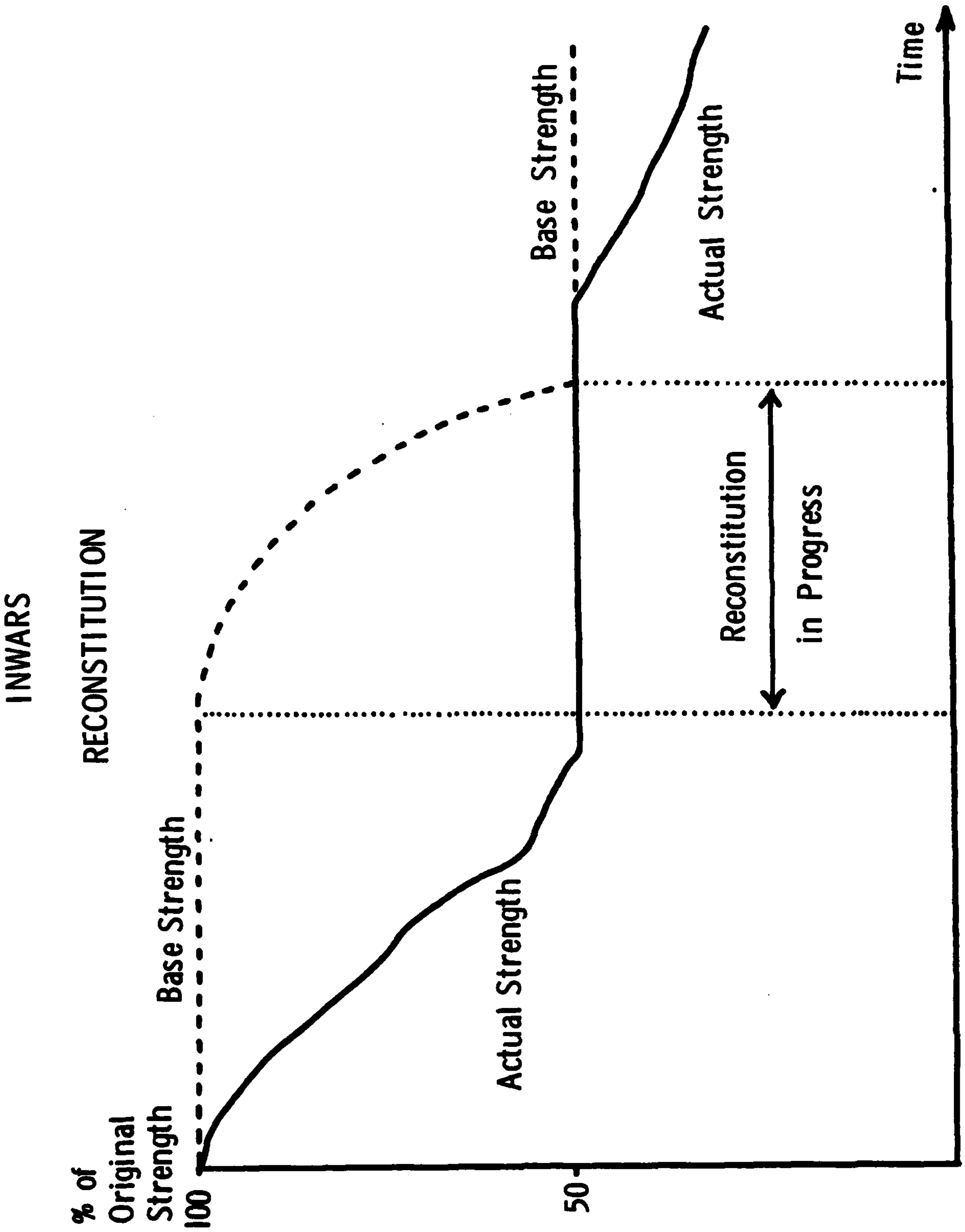


Figure VII-1. Reconstitution Cycle

2. The Reconstitution Process

The process of reconstitution can be described as reducing the base strength to more nearly match the present strength for each weapon/ asset type. This process can be implemented by the following formula:

$$N_b(t+1) = N_b(t) - r \quad N_b(t) \quad .$$

In this case, the rate at which the base is reduced is proportional to the current casualty level. This causes units which have suffered severe attrition to recover much more slowly.

C. REPLACEMENTS

A unit which has suffered attrition may be aided by the use of replacements. In its simplest form, this consists of making available individual weapons and assets to fill the holes in the organization left by casualties. On the other hand, replacements added in the form of entire units and organizations would take less time to incorporate, *although the* remainder of the unit would still require reorganization. Figure VII-2 illustrates this process.

1. Replacement of Individuals

This process requires that the number of replacements be immediately added to the present strength. If the replacements are of sufficient quantity, this would bring the unit immediately to full effectiveness unless the base strength is also changed. It is planned that the number of replacements also be added to the base strength. This will result in the unit taking an immediate jump in effectiveness, but full effectiveness being gained only after a period of time.

2. Replacement of Units

In this case entire organizations are added to the unit. While some reorganization would still be necessary, it would be at a higher level and hence, it is assumed, faster. This will be accomplished by

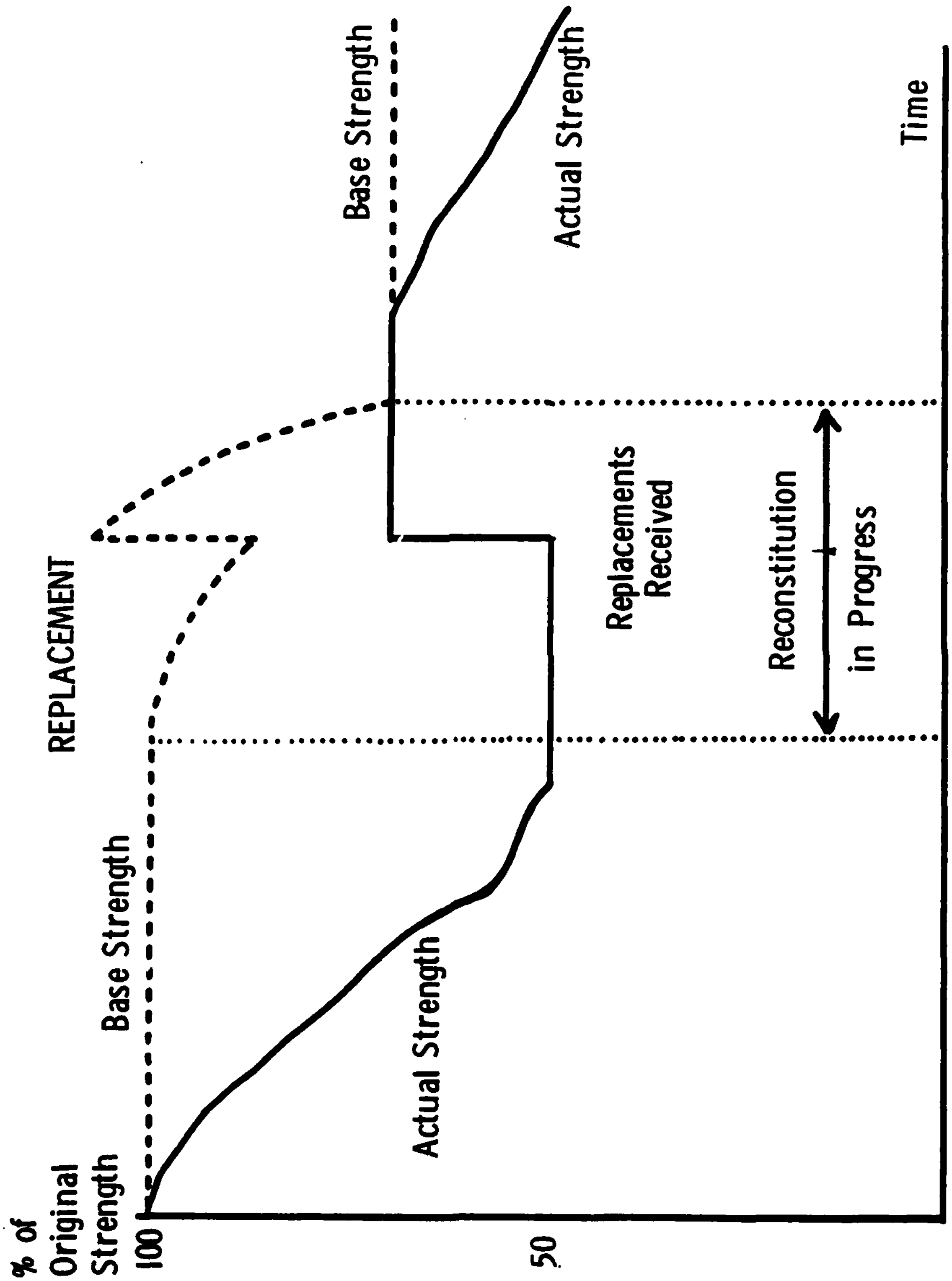


Figure VII-2. Replacement During Reconstitution

dividing the addition to base strength by an amount dependent on the organizational level of the replacement units(s).

D. ASSESSMENT

Above, reconstitution was viewed as a distinct activity which takes place essentially in isolation. However, such activity often occurs in other situations as well. If the process of decreasing the base strength toward the actual strength usefully describes the process of reorganization, then the inverse operation might serve usefully to model effects of disorganization resulting from other then attrition effects. Another consideration is that the addition and integration of replacements cannot make up for the loss of the men who had trained together; the reconstituted unit cannot really be made completely whole again. Various refinements are possible to treat some of these effects, if warranted by test and experimentation.